On the Causes and Effects of Exchange Rate Volatility on Economic Growth: Evidence from Ghana

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ABSTRACT

What drives exchange rate volatility, and what are the effects of fluctuations in the exchange rate on economic growth in Ghana? These questions are the subject matter of this study. The results showed that while shocks to the exchange rate are mean reverting, misalignments tend to correct very sluggishly, with painful consequences in the short run as economic agents recalibrate their consumption and investment choices. About three quarters of shocks to the real exchange rate are self-driven, and the remaining one quarter or so is attributed to factors such as government expenditure and money supply growth, terms of trade and output shocks. Excessive volatility is found to be detrimental to economic growth; however, this is only up to a point as growth-enhancing effect can also emanate from innovation, and more efficient resource allocation.

1. Introduction

Exchange rate volatility – defined as the persistent fluctuations of the exchange rate – has dominated recent literature in international finance owing to its effects on developing economies. In both developed and developing economies, concerns about exchange rate fluctuations have evolved in an astonishing manner largely on its impact on exports (Arize, Osang, & Slottje, 2000; Assery & Peel, 1991; Bahmani-Oskooee & Hegerty, 2007; Vieira & MacDonald, 2016; Wang & Barrett, 2007), employment growth (Belke & Setzer, 2003; Belke & Kaas, 2004), trade (Bredin, Fountas, & Murphy, 2003; Clark, Tamirisa, & Wei, 2004; Doyle, 2001; Musila & Al-Zyoud, 2012; Tenreyro, 2007); inflation (Danjuma, Shuaibu, & Sa'id, 2013); investment (Fuentes, 2006; Kiyota & Urata, 2004; Serven, 2002), and more generally economic activity (Adewuyi & Akpokodje, 2013; Kandil, 2004) and growth (Danne, 2006; Holland et al. 2011; Levy-Yeyati & Sturzenegger, 2003; Mundell, 1995).

In Ghana, the advent of the Financial Sector Adjustment Programme (FINSAP) – a component of the Economic Recovery Program (ERP) – introduced major reforms in the financial sector including the jettison of the fixed exchange rates in favor of the free floating regime in the 1980s. Among others, this transition was done under the premise

that flexible exchange rates would curb the boom-and-bust syndrome as well as turn the country towards a trajectory of growth with the growth-enhancing effect emanating from the exchange rate pass-through on consumer prices, terms of trade, trade volumes and investments.

Since the adoption of the flexible exchange rate regime in the 1980s, the Ghana Cedi has depreciated against major currencies especially the US Dollar (US$), albeit, not monotonically, as the Ghana Cedi recorded a modicum of stability between 2002 and 2007. Ghana redenominated her currency on July 1, 2007 where US$1 was exchanged for 93 pesewas. This move saw a depreciation of the Cedi overtime and by the end of July, 2009, the US$ was exchanged for GH¢1.49. Most recently, the Cedi has been very volatile and depreciated by 44.65% between January, 2014 to September, 2014. Arguably, this level of depreciation contributed to a rise in consumer price inflation which stood at 17% in December, 2014 from 13.8% in January, 2014. GDP growth which stood at 15.0% in 2011 dropped to 8.8% in 2012 and further to 7.6% in 2013. In fact, GDP growth rate for 2014 was 4.2% down from a revised initial target of 7.1%.

While anecdotally the volatility of exchange rate has been linked to macroeconomic instability, very little attempt has been made to examine the factors behind it and the impact it has for both internal and external stability. Moreover, discussions surrounding the fluctuations in Ghana's exchange rate are only gleaned from public discourses on the economy with very little empirical and theoretical content. Understanding the key drivers of exchange rate volatility and the channels of manifestation is an empirical matter and this study examines the causes of exchange rate volatility and its impact on growth performance with the view to informing policy towards maintaining stable currency.

This study critically analyzes the causes of real exchange rate volatility and its effect on economic growth in Ghana relying on annual data spanning 1980 to 2013. Results from the cointegration test show existence of long-run relationship among the variables implying that as shock hit the economy causing short-run disequilibrium, real exchange rate moves to restore equilibrium albeit sluggishly. Results from the vector error correction model (VECM) indicate that in the short-run, only output significantly drives exchange rate fluctuations. However, findings from the normalized cointegrating equation reveal that volatility is significantly influenced by government expenditure, money supply, terms of trade, FDI and output. Variance decompositions show that, exchange rate volatility is own-driven. Furthermore, FDI and output are visible factors explaining majority of the forecast error of volatility relative to other factors. We document a rather U-shaped relationship between real exchange rate fluctuation and long-term growth suggesting that effect on growth of volatility is not always deleterious.

The rest of the study is as follows. Section 2 presents a review of Ghana exchange rate policy while Section 3 discusses the empirical literature on the causes of exchange rate volatility and its effects on economic growth. Section 4 outlines the empirical strategy and model specifications while Section 5 presents the empirical results. We discuss the implications of the long and short run determinants of exchange rate volatility and the volatility growth-nexus in Section 6. Section 7 concludes.

2. A review of Ghana's exchange rate policy

Ghana's foreign exchange market has undergone significant changes over the past three decades. An interesting diagnostic analysis is provided by Jebuni, Sowa, and Tutu (1991) who categorized the exchange rate regimes into pre-ERP and the ERP periods. We introduced an additional period spanning 2000 to 2014 on account of major restructuring of the foreign exchange market. Ghana was a member of the British West African Currency Board (WACB) constituted in 1912. Under this regime, the Board was responsible for the issuance of currency notes and coins as legal tender within the four British colonies (Ghana, Nigeria, Sierra Leone and The Gambia). However, prior to independence in 1957, Ghana renounced her membership to the WACB thus adopting a fixed exchange rate policy. In November, 1958, the country brought forth a new currency – the Ghana pound – which was set at par with the British pound sterling and exchanged for US$2.80. In 1965, a new currency – Cedi – was introduced to replace the Ghana pound and was subsequently pegged at 2.4 Cedis to 1 British pound and 1 Cedi to US$1.166.

In February, 1967, the Cedi was replaced by the new Cedi taking the value 1.2 times the "old" Cedi. The external value of the Cedi was pegged at US$1 = 0.714 new Cedi. In terms of the British pound, the new Cedi was initially fixed at 2 Cedis = 1 British pound but was shortly devalued to 2.45 Cedis = 1 British pound while maintaining the new Cedi–US$ exchange rate (Kwakye, 2012). The economy was thought to be taking a nosedive. Firms produced below capacity owing to lack of raw materials. Exports stagnated and imports became expensive. Growth rate of GDP per capita was on a sharp decline and the National Liberation Council (NLC) government sought bailout from the International Monetary Fund (IMF) and the World Bank. Consequently, Ghana adopted the economic package and reforms of the international financial institutions and in July, 1967. The rate was fixed at US$1 to 1.02 Cedis.

In November 1967, the British pound was devalued from 1 British pound = US$2.8 to 1 British pound = US$2.4. Although Ghana's currency remained pegged to the British pound, it did not devalue her currency. As a result of the unsustainable balance of payments coupled with the erosion of foreign reserves, the Cedi was devalued in December 1971 to a fixed rate of US$1 = 1.82 Cedis and then later revalued to US$0.78 in 1972. However, the Cedi gained about 25% of its value following a coup d etat on January 13, 1972 which saw the ousting of Busia's Progress Party by the NLC government of Col. Ignatius Acheampong. In the aftermath of the coup, Ghana's currency was devalued to US$0.87 in early 1973 and in June 1978, the flexible exchange rate system was adopted where the Cedi–US$ rate was amended to reflect the prevailing macro-economic conditions. During this period, the Cedi remained pegged to the British pound and US$ and in August, 1978, the Cedi–US$ rate was fixed at US$1 = 2.75 Cedis on account of the rather high inflation which eroded the value of the Cedi. Although the real exchange rate depreciated in 1979, it continued to show signs of gains from 1980 to 1982 (Jebuni et al., 1991).

The Ghanaian economy faced serious challenges including but not limited to shortage of currency and the "ballooned" inflation rate which hit a record high of 123% in 1983. This period marks the starting point of the second episode – the ERP – where the government commenced a gradual devaluation of the Cedi accompanied by other

systematic economic adjustments. These adjustments were done within the context of the ERP. The financial sector saw major changes owing to the launch of the FINSAP. In 1986, the fixed exchange rate system was abandoned in favor of the "managed" floating regime where rates were determined by the auction market. The adoption of the floating exchange rate system which meant that, the value of the Cedi was freely determined through the interplay of the market forces, saw the Cedi depreciate by 96% in 1987 (Tarawalie et al., 2012). Sowa and Acquaye (1999) found that the liberalization of Ghana's financial and foreign exchange markets weakly impacted on exports and imports continued unabated even in the face of currency depreciation. While the liberalization efforts were inflationary largely through money supply and output, it generally improved the allocative efficiency of the financial markets.

The foreign exchange bureau system was established to integrate the parallel market into the legal foreign exchange market. The weekly auction was abolished in 1990 in favor of the wholesale auction which institutionalized the composite exchange rate system notably the inter-bank and the wholesale auction system. However, in April 1992, the wholesale auction system was abandoned thus opening both the commercial banks and foreign exchange bureau to a competitive financial environment. The exchange rate continued to depreciate albeit some gains and the real effective exchange rate which was US$1 = 123.92 Cedis in 1993 was exchanged for US$1 = 140.49 in 1999. Consequently, the Cedi depreciated by 99.4% in 2000 partly due to the country's general elections of that year.

The final episode which we called the stabilization phase spans from 2000 to 2014. In the post-electoral period and between 2001 and 2006 in particular, the rate at which the Cedi was depreciating stabilized and in July 2007 a new currency – Ghana Cedi – was introduced while maintaining the external purchasing power of the currency. For instance, the Ghana Cedi (GH¢) – US$ exchange rate which was 9,200 Cedis to US$1 at the time this reform became GH¢0.92 = US$1. This means that, the currency was neither devalued nor revalued but was redenominated. However, since the redenomination, the value of the Ghana Cedi continued to depreciate partly due to rising inflation and the currency reform more generally. By August 2012, the Ghana Cedi had depreciated to GH¢1.89 = US$1 and further down to GH¢2.21 in December, 2013 albeit not monotonic. In effect, importing firms incurred higher cost of production translating into higher consumer prices and in January, 2014, a Dollar was exchanged for GH¢2.39.

To halt the currency from further depreciation, the Bank of Ghana on February 4, 2014 issued a directive on the operations of Foreign Exchange Accounts (FEA) and Foreign Currency Accounts (FCA). Among the new directives for the FEA included the ban of transfers from one foreign currency denominated account to another and abrogation of all checks issued on FEA. It further directed banks to convert all undrawn foreign currency denominated facilities into the Ghana Cedi and to stop granting a foreign currency denominated loan to a non-foreign exchange earner. These draconian measures constituted a knee-jerk reaction by the Central Bank to restore stability by putting the cart before the horse. It was therefore not surprising when the directives failed to produce the intended impact but rather limited access to foreign exchange, restricted intra-trade, contracted deposits and credits and increased the operations of the black market. These exacerbated the pressure on businesses as the directives

compounded the deterioration of the exchange rate which stood at GH¢2.89 = US$1 in May 2014, and by August 2014 the Central Bank reversed their earlier foreign exchange measures.

Conclusively, Ghana has gone through several episodes and policies aimed at stabilizing exchange rate but the rather volatile nature of it has left policymakers beleaguered with a quandary as to which factors significantly drive exchange rate movements.

3. Exchange rate volatility and economic growth: a review

Following Meese and Rogoff's (1983) seminal work, forecasting exchange rates using models that condition on economically meaningful variables has long been a topical issue in international finance literature although empirical studies remain vague. Even though some studies (see Mark, 1995; Mark & Sul, 2001) find evidence that exchange rates co-move with macroeconomic fundamentals over long horizons, contemporary literature in international finance is that exchange rates are unpredictable, especially at short horizons (Corte, Sarno, & Tsiakas, 2009). More recently, Li, Tsiakas, and Wang (2015) assess the economic value of out-of-sample exchange rate predictability by analyzing the performance of dynamically rebalanced portfolios using one-month ahead forecasts generated by recursive regressions. Findings from their study show that, a risk-averse investor on average is willing to pay a fee of at least 4% annually to be able to use the efficient kitchen-sink forecasts rather than the random walk. Similarly, Corte et al. (2009) examine the economic value of both in-sample and out-of-sample forecasting power of the empirical exchange rate models and find that, a risk-averse investor will pay a high performance fee in order to switch from a dynamic portfolio strategy based on a random walk model to one that conditions on the forward premium with stochastic volatility innovations.[1]

Indeed, a critical concern in the literature has also been on exchange rate volatility–economic growth nexus although the theoretical literature is still a matter of great debate among economists. At the theoretical level, while some studies (see Obstfeld & Rogoff, 1998) posit that large swings in exchange rates can be costly to the domestic economy, studies such as Devereux and Engel (2003) contend that the welfare effects of exchange rate volatility are conditional upon the manner in which prices are set. The empirical literature is equally unsettled regarding the effects of exchange rate volatility on economic growth. In this brief review we survey the literature with the view to disentangle the various factors documented in the literature as important in driving the exchange rate volatility–growth nexus.

Following the liberalization of global foreign exchange markets, MacDonald and Nagayasu (1999) identify two compelling areas of particular interest for exchange rate dynamics: (i) a significant long-run relationship between real exchange and fundamentals and (ii) the relative significance of shocks in total exchange rate volatility. Generally, the causes of exchange rate volatility can be grouped into domestic real shocks affecting supply, domestic real shocks affecting demand, external real shocks and nominal shocks reflecting changes in money supply. In the standard Dornbursch (1976) model, unanticipated monetary policy shocks generate large variations in the exchange rate. Here, nominal shocks affect real exchange rate but only in the short run. Because real

exchange rate deviates from its long-run equilibrium path, extant studies on the cause of the deviations and results are largely torn between two schools. The first documents significant relationships between real exchange rate fundamentals including supply and demand factors where the former largely relate to the level of output capacity and expected to follow the Balassa–Samuelson hypothesis. This hypothesis assumes that productivity increases tradable sectors hence pushing up sector wages. This in effect puts an upward pressure on wages in the non-tradable sector and the economy as a whole. Because productivity does not increase in response to wage rise, prices of non-tradable goods are expected to rise leading to increase in the relative price of non-tradable to tradable goods, hence, an appreciation of the domestic real exchange rate. The demand factors relate to the role of government expenditure while the external shocks reflect changes in terms of trade, trade openness and capital flows. The second strand identifies the effects of real shocks in exchange rate volatility.

According to Clarida and Gali (1994), business cycles shocks are at the heart of fluctuations in real exchange rate. Gauthier and Tessier (2002) assess the effect of supply shock on the real exchange rate dynamics in Canada by employing the structural vector error correction model. They found that while majority of the stochastic depreciation of the exchange rate is accounted for by supply shocks, results from their study contradict the Balassa–Samuelson hypothesis as they found the exchange rate to appreciate in response to a positive supply shock. For studies pertaining to developing countries, Kandil and Mirzaie's (2008) decomposition of exchange rate movements into anticipated and unanticipated concludes theoretically that the unanticipated exchange rate movements significantly determine aggregate demand via exports, imports and the demand for local currency. However, unanticipated currency fluctuations affect aggregate supply through the cost of imported inputs. Conversely, the effect of anticipated increase in exchange rate on the supply channel has a limited effect on output growth and price. Hausmann, Panizza, and Rigobon (2006) reveal that developing countries' real exchange rate is more volatile than that of industrialized countries on account of high exposure to shocks (both real and nominal) by variations in the sensitivity of real exchange rate to shocks.

While a plethora of studies exist on the causes of exchange rate volatility, some authors remain skeptical whether volatility actually impacts on welfare. For instance, Devereux and Engel (2003) show that exchange rate volatility does not entail welfare cost and argue that domestic consumption is unaffected if prices are fixed to the currency of the foreign country. However, Obstfeld and Rogoff's (1998) theoretical work reveals that exchange rate volatility is indeed costly to the domestic economy through its direct and indirect effects on households and firms respectively. The former effect is based on the premise that households remain unhappy about exchange rate movements because of the difficulty in consumption smoothening as well as fluctuations in leisure consumption. The indirect effect however assumes that, in an attempt to hedge exchange rate risk, firms set higher prices in the form of risk premium. Empirically, Pallage and Robe (2003) found that in many poor countries, the welfare gain from expunging volatility could far outweigh the welfare gain from percentage-point increase in growth. Straub and Tchakarov (2004) also found evidence that even small effects of non-fundamental volatility can have a large effect on welfare.

On whether exchange rate volatility impacts on growth, Dollar (1992) found a negative relationship between growth and exchange rate volatility in a sample of 95 developing countries. Bosworth, Collins, and Chen's (1995) study shows that real exchange rate volatility reduces growth by lowering total factor productivity. Kandil (2004) examines the effects of exchange rate fluctuations on real output growth and price inflation in a sample of 22 developing countries. The authors argue that depending on the degree of openness, exchange rate volatility and depreciation in particular hurts economic performance by contracting output growth and inflation. In the long run, anticipated exchange rate fluctuations significantly increase and decrease inflation and output growth respectively.

Holland et al. (2011) examine the impact of real exchange rate volatility on long-run economic growth for advanced and emerging economies over the period 1970 to 2009 and found that, high (low) exchange rate volatility positively (negatively) affects real GDP growth rate. However, controlling for exchange rate volatility in a model containing levels of exchange rate and exchange rate misalignment renders the variables insignificant suggesting that exchange rate stability is more crucial in propelling long-run growth than exchange rate misalignment. However, while finding no significant link between exchange rate volatility and long-run productivity growth, Gadanecz and Mehrotra's (2013) recent study reveal non-linearities between real exchange rate volatility and output volatility among emerging market economies. Their finding suggests that real exchange rate volatility aids in absorbing shock as well as limiting output volatility, but too much of volatility in exchange rate increases output volatility.

Eichengreen (2008) argues that maintaining appropriate and stable exchange rate volatility enables countries to explore their growth and development capacities. Excess exchange rate volatility has been identified to reduce the level of economic growth by creating business uncertainty, deteriorating competitiveness, lowering productivity and profits as well as increasing domestic prices. This clearly has welfare implications and should be a policy concern. Changes in real exchange rate need to be guided by aligning exchange rate with fundamentals. This in effect maintains external competitiveness and domestic stability. In this study, we attempt to closely identify the causes of exchange rate volatility and the dynamic linkages between exchange rate volatility and economic growth in Ghana.

4. Data and empirical strategy

4.1. *Data description and definition of variables*

Data on exchange rate is available at different frequency. This study however, relies on annual time series data because our analyses are based on other macroeconomic variables only available annually thus restricting the use of monthly or quarterly data where larger sample is assured. Data for this study are gleaned from different sources. Data on nominal exchange rates (RER) and interest rates (INTR) are obtained from the Bank of Ghana and Datastream. Data on real GDP per capita (RGDP), trade openness (OPEN), government expenditure (GEXP), money supply (MS), foreign direct investment and portfolio flows (FDI), output (OUTPUT), terms of trade (TOT), domestic credit provided to private sector (DOMCR), labor (LAB), gross fixed capital formation

(GFCF) and inflation (INFL) were sourced from the World Development Indicators (WDI) of the World Bank. Real GDP per capita is used to denote economic growth while trade openness is defined as the ratio of the summation of imports and export to nominal GDP. Government expenditure is used as a measure of final government consumption expenditure expressed as a percentage of GDP. The money supply variable is proxied by broad money taken as proportion of GDP. FDI (net inflows) is expressed as a percentage of GDP and taken to include portfolio investments. This variable is used to proxy the country's integration with the international financial markets. The output variable refers to real GDP measured on annual basis in millions of US$, with 2000 as the base year. Terms of trade is the net barter terms of trade index, computed as the percentage ratio of the export unit value indexes to the import unit value indexes, using year 2000 as a reference. Labor is proxied by the percentage of economically active population. Domestic credit is measured relative to GDP and used to denote the financial resources provided by banks to the private sector. Capital formation is used as a proxy for investment rates and measured as a percentage of GDP. The inflation variable is the annual percentage change in the consumer price index and used to proxy macroeconomic (in)stability. Time series data for all the variables spanned 1980 to 2013 thus covering a 34-year period. This period is particularly relevant for the study as it captures Ghana's pre-transition period from fixed to a fairly floating regime. The period also coincides with the launch of the ERP.

4.2. *Empirical strategy*

Because changes in world prices or fluctuations in nominal exchange rate leads to instability in international commodity trade, this paper uses the real exchange rate to capture the effect of inflation differentials to provide a robust measure of the price of foreign currency in real terms. Following this, we construct our measure of real effective exchange (RER) as follows:

$$RER = NER \times P^w / CPI \qquad (1)$$

where NER is the nominal exchange rate defined as the amount of GH¢ needed to exchange US$1; P^w is the US price level proxied by the wholesale price index while CPI is the consumer price index reflecting domestic price levels. Thus, a rise (fall) in RER implies a real depreciation (real appreciation) of the Cedi.

4.2.1. *Modelling volatility*
To measure volatility, some authors have used the standard deviations where exchange rate volatility is measured according to the degree to which exchange rate fluctuates in relation to its mean overtime (Gadanecz & Mehrotra, 2013; Schnabl, 2007). Using this measure is not without challenges. First, it assumes that, the empirical distribution of the exchange rate is normal. Second, it does not reflect the distribution between an unpredictable component of the exchange rate process hence failing to capture the past information of the exchange rate. The empirical flaws of this measure restricts its use hence the use of the autoregressive conditional heteroskedasticity (ARCH) or generalized ARCH (GARCH). In this study, we rely on the GARCH developed by Bollerslev

(1986) not only because exchange rate best follow the GARCH process (McKenzie, 1999), but because it captures past values of the exchange rate as opposed to the ARCH. Allowing the log of the real exchange rate to depend on its previous value for the mean equation, we derive our GARCH model as follows:

$$\text{InRER}_t = \propto_1 + \beta^| \text{InRER}_{t-1} + \mu_t \tag{2}$$
$$\mu_t | \Omega_t \sim iid \, \text{N}(0, h_t)$$

$$h_t = \gamma_0 + \delta \mu_{t-1}^2 + \varphi h_{t-1} \tag{3}$$

where $\gamma_0 > 0$, $\delta \geq 0$ and $\varphi \geq 0$

Therefore, our conditional variance h_t captures the mean (γ_0), information about the previous volatility, μ_{t-1}^2 (ARCH term) and the past forecast error variance, h_{t-1} (GARCH term). Thus, our GARCH model allows the error term to have a time varying variance conditional on the past behaviour of the series hence reflecting the actual volatilities as perceived by agents.

The first step in determining cointegration is to test the integration properties of our variables relying on three different unit root tests: augmented Dickey–Fuller test (Dickey & Fuller, 1979); Phillip–Perron test (Phillip & Perron, 1988) and the Kwiatkowski et al. (1992) test. We compute the real exchange rate volatility in a vector autoregressive (VAR) model in the framework of Johansen and Juselius (1990) cointegration in order to determine the short- and long-run causes of real exchange rate volatility.

Starting with the VAR(q), we define Y_t as the unrestricted vector of variables integrated of order one ($I(1)$) as follows:

$$Y_t = A_0 + A_1 Y_{t-1} + \ldots\ldots\ldots\ldots + A_q Y_{t-q} + \varepsilon_t \tag{4}$$

where Y_t is $n \times 1$ vector; A's is an $n \times n$ matrices of parameters and ε_t is an $n \times 1$ vector of constant terms. The vector error correction model (VECM) can then be formulated by estimating the above equation in its first difference form as follows:

$$\Delta Y_t = \mu + \Gamma_1 \Delta Y_{t-1} + \ldots\ldots\ldots\ldots + \Gamma_{q-1} \Delta Y_{t-q-1} + \Pi Y_{t-q} + \varepsilon_t \tag{5}$$

where Δ is the difference operator; $\Gamma_i = \left(I - A_1 - A_2 - \ldots\ldots\ldots\ldots - A_q\right)(i = 1, 2, \ldots\ldots q{-}1)$, $\Pi = -\left(I - A_1 - A_2 - \ldots\ldots\ldots\ldots - A_q\right)$, I is the identity matrix while $\Pi = n \times n$. While Γ_i captures the short–run effects, Π measures the long-run changes in Y_t. We remodel equation (2) into an error correction model as:

$$\Delta Y_t = \mu + \sum_{q-1}^{i=1} \Gamma_i \Delta Y_{t-1} + \Pi_i X_{t-q} + \varepsilon_t \tag{6}$$

The Johansen approach specifies the rank of matrix Π and can be further formulated as $\Pi = \alpha\beta'$ where α denotes the adjustment parameters entering each equation of the VECM while β' contains information about the long-run matrix of coefficients with α and β matrices dimensioned $n \times r$. When Π has a full rank (that is $r = n$), then our variables in Y_t would be stationary. However, when the rank of Π is zero (that is non-existence of linear combination of the variables in Y_t), then there would be no

cointegration. Meanwhile, when ⬚ has a reduced rank $0 < r < n$, then there would be r cointegrating relationships. The trace test statistics is used to determine the number of cointegration equations: the trace and maximum eigenvalue tests which test where the former and latter respectively tests the null hypothesis of at most r cointegrating relation. The appropriate lag length of the VECM is chosen according to the Akaike's information criterion as shown in Table A1 in the Appendix. We examine the effect of exogenous shock on exchange rate volatility using the impulse response function and variance decompositions of the forecast errors based on the VAR.

The second overarching aim of this paper is to determine the effect of exchange rate volatility on growth. On this score, our empirical strategy is based on estimation of a simple baseline equation relating growth and exchange rate volatility to a set of standard controls augmented by initial growth condition. In other words, we estimate the following growth equation:

$$y_t = \varpi_0 + \varpi_1 y_{t-1} + \varpi_2 \text{RERV}_t + \varpi_3 Z_t + \varepsilon_t \qquad (7)$$

where y_t is economic growth at time t proxied by log of real GDP per capita; y_{t-1} is the initial growth condition; RERV_t is the exchange rate volatility at time t; Z_t is a vector of control variables including gross fixed capital formation, government expenditure, labor, inflation, trade openness and indicators of financial development while ε_t is the error term.

The expected signs of the coefficients of our controls follow the standard growth literature which hypothesizes a positive relationship between growth, capital stock and labor. Terms of trade, financial development and openness are also expected to propel growth. While inflation is expected to negatively influence growth; the coefficient of government expenditure is mixed. Following from the Keynesian proposition, we expect government spending to boost economic growth by raising aggregate demand. However, higher government expenditure could also negatively affect growth because of crowding-out effect of private investment especially when the expenditure is heavily financed with taxes. It is imperative to note that, the inclusion of lag dependent variable poses potential endogeneity problems. To address this, the study utilizes the generalized methods of moments (GMM) developed by Arellano and Bover (1995) which combines the equation of interest in first differences (with lagged levels as instruments) and in levels (using lagged differences as instruments). We used the lags of the regressors as instruments in the GMM estimations. However, yielding robust GMM estimator depends on the validity of the instruments and this is checked using Hansen's test of over-identification of restrictions which evaluates the validity of the instrument subset by testing the null hypothesis that the set of identified instruments are uncorrelated with the residuals. In this test, failure to reject the null hypothesis show robust instruments. However, if the null hypothesis is rejected, we conclude that the estimators are not robust because the restrictions imposed by relying on the instruments are invalid. We also include a square of exchange rate volatility in the growth equation in order to examine possible non-linearities and threshold effect of volatility on growth. We posit three main channels through which exchange rate stability affects growth: interest rate (as influenced by debts of firms denominated in foreign currency), trade (as influenced by international competitiveness) and macroeconomic stability (as

influenced by a favorable environment for investment and consumption). We examine the transmission channels of volatility to growth by including in our growth equation (7), the interaction terms of exchange rate volatility and each of the channels. Regarding a prior expectation, exchange rate stability is expected to promote growth by lowering interest rates, promoting trade and subsequently lowering inflation. We use the 91-Day Treasury bill rate to proxy interest rate while trade and macroeconomic stability are proxied by exports and inflation respectively.

5. Results and discussions

5.1. *Preliminary analysis*

This section presents the results of our empirical analysis. We start by showing descriptive statistics of the indicators employed in our study. This gives us a good idea of the patterns in the data and the nature of the estimations and diagnostics to be carried out. Tables 1 and 2 respectfully present the descriptive statistics and correlation coefficients of the variables.

While the mean value of the real exchange rate is GH¢3.69, the value of the standard deviation is 5.97 showing some degree of variability. The value of the skewness shows

Table 1. Descriptive Statistics.

	Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	J-B	CV
RER	3.69	0.44	21.75	0.00	5.97	1.85	5.38	27.44 [0.00]	1.62
TOT	133.67	125.42	209.52	89.22	32.30	0.72	2.43	3.39 [0.18]	0.24
RGDP	455.26	417.71	769.28	320.77	112.97	1.28	3.95	10.53 [0.01]	0.25
OPEN	62.72	65.64	116.05	6.32	31.08	-0.19	2.00	1.63 [0.44]	0.50
MS	22.59	22.69	34.11	11.30	6.93	0.00	1.70	2.41 [0.30]	0.31
DOMCR	8.47	7.11	16.00	1.54	5.19	0.12	1.39	3.77 [0.15]	0.61
EXPORT	26.02	25.11	48.80	3.34	13.20	0.04	1.99	1.46 [0.48]	0.51
FDI	2.58	1.61	9.52	0.05	2.97	1.17	3.00	7.78 [0.02]	1.15
GEXP	11.35	11.12	20.99	5.86	2.94	1.07	5.16	13.13 [0.00]	0.26
OUTPUT	8.5E+09	7.3E+09	2.0E+10	3.8E+09	4.4E+09	1.09	3.34	6.85 [0.03]	0.51
GFCF	18.04	20.57	31.13	3.53	7.78	−0.43	2.07	2.25 [0.32]	0.43
INFL	28.93	23.44	122.87	8.73	26.36	2.47	9.00	85.68 [0.00]	0.91
INTR	23.60	21.12	47.89	9.94	10.89	0.66	2.41	2.94 [0.23]	0.46
LAB	54.76	54.68	58.06	51.68	1.98	0.06	1.74	2.29 [0.32]	0.04

Notes: RER= real exchange rate, TOT= terms of trade, RGDP= real GDP, OPEN= trade openness, MS= money supply, DOMCR= domestic credit, EXPORT= export, FDI = foreign direct investment and portfolio investment, GEXP= government expenditure, OUTPUT= output, GFCF= gross fixed capital formation, INFL= inflation, INTR= interest rate, LAB= labour. Number of Observations= 34. *p*–values are shown in [].

Table 2. Correlation Coefficients.

Variables	RERV	OUTPUT	MS	TOT	RGDP	INTR	FDI
RERV	1.000						
	−						
OUTPUT	−0.591*	1.000					
	[0.000]	−					
MS	−0.606*	0.761*	1.000				
	[0.000]	[0.000]	−				
TOT	0.135	0.587*	0.246	1.000			
	[0.453]	[0.000]	[0.168]	−			
RGDP	−0.545*	0.996*	0.736*	0.614*	1.000		
	[0.001]	[0.000]	[0.000]	[0.000]	−		
INTR	−0.327*	−0.170	0.120	−0.560*	−0.186	1.000	
	[0.063]	[0.346]	[0.505]	[0.001]	[0.301]	−	
FDI	−0.486*	0.865*	0.599*	0.575*	0.858*	−0.142	1.000
	[0.004]	[0.000]	[0.000]	[0.001]	[0.000]	[0.431]	−

Note: Variable definition and comments same as Table 1.

real exchange rate is highly skewed to the right. The value of the kurtosis and skewness show a non-normal distribution of real exchange rate suggesting that our exchange rate distribution is leptokurtic. A formal test of normality is the Jarque-Bera (J-B) test which is asymptotically chi-squared distributed with 2 degrees of freedom (Asteriou & Hall, 2011). From Table 1 we report a high J-B test statistic for the real exchange rate, real GDP, FDI, government expenditure, output and inflation, thus flatly rejecting the null hypothesis of normality in these series. The non-normality of the exchange rate is akin to empirical evidence in the literature (see Kwek & Koay, 2006 for instance). Broad money supply (MS) is perfectly symmetrical given the value of its skewness and has a mean value of 22.59%. Apart from being normally distributed given the J-B test statistic and p-value, money supply does not show much variability over the sample period. Furthermore, with the exception of trade openness (OPEN) and gross fixed capital formation (GFCF), all the variables are positively skewed. The average real GDP per capita is US$455.26 reiterating the low income level of Ghana during the sample period. Also, its standard deviation shows significant variations in the income levels. While the standard deviation measures absolute variability, the coefficient of variation (CV) computed as the ratio of standard deviation to mean measures the relative dispersion of the variables. This implies that the higher the CV, the greater the variability thus allowing the direct comparison of the relative volatility of our series given the differences in means. The results suggest that the most volatile variable is real exchange rate. Exogenous variables vary far less than exchange rate. Real variables exhibit different levels of variability with terms of trade showing the least. Volatility in FDI and portfolio is exceedingly higher than the terms of trade, government expenditure and output. Among the exogenous variables, inflation exhibited more volatility given its relatively higher CV followed by domestic credit. Trade openness and export show similar variability perhaps due to the direct relationships.

Table 2 presents the correlation coefficients of real exchange rate volatility and other variables including real GDP per capita, money supply, terms of trade, output, interest rate and FDI. Here, we pay special attention to the correlation between real exchange rate and all the other variables. Our results suggest that, real exchange rate volatility is negatively and significantly correlated with all the variables except terms of trade which

is positive and insignificant. Correlations between real exchange rate volatility and money supply on one hand and exchange rate volatility and output on the other hand are much stronger. Real GDP is positively correlated with output, money supply and terms of trade. These correlations are unsurprising given the role of productivity, financial deepening and terms of trade in GDP. Apart from volatility, terms of trade positively correlates with output and money supply. However, only its correlation with output is significant.

5.2. *Estimation of real exchange rate volatility*

This section presents the results of the estimation of exchange rate volatility using a GARCH (1, 1) model (see Table 3). The robustness of our results is examined to ensure model adequacy. The Ljung-Box statistics on the standardized residuals and the standardized squared residuals of the estimated GARCH models show no evidence of serial correlation. And so is the ARCH LM test which suggests that there is no evidence of conditional heteroskedasticity given the rather low LM statistic (8.0651) and high p-value (0.7800).

Results from the conditional variable equation reveal that the mean γ_0 from equation (3) is positive albeit insignificant. The previous forecast error – GARCH term (h_{t-1}) – is however positive and significant at 1%. Interestingly, further results reveal that previous information about the real exchange rate volatility as measured by the squared residual (μ_{t-1}^2) from the mean equation is negative and flatly insignificant at conventional levels. The insignificance of the ARCH effect is consistent with LM test on the residuals thus indicating that GARCH specification is appropriate for modelling exchange rate volatility. The sum of the coefficient on the lagged squared error (δ) and lagged conditional variance (φ) is very close to unity ($0.93 \approx 1$) implying that volatility shocks are highly persistent suggesting the presence of volatility clustering – a period where large (small)

Table 3. Estimation of Real Exchange Rate Volatility.

Variable	Coefficient
Mean equation	
Constant	0.1183
	(3.572)***
LRER(−1)	0.9359
	(30.51)***
Variance equation	
Constant	0.0008
	(0.241)
ARCH(1)	−0.2201
	(−0.870)
GARCH(1)	1.154***
	(3.271)
LBQ[12]	15.834[0.199]
LBQ^2[12]	8.801[0.720]
ARCH[12]	8.0651[0.7800]
ARCH[1]	0.00202 [0.9642]

Notes: Test statistics are shown in () while *p*-values are in []. LBQ[12] and LBQ^2 [12] are the Ljung-Box test on the residuals and the squared residuals of the GARCH model for 12 lags respectively. ARCH [1] and ARCH [12] is the Lagrange Multiplier (LM) test on the residuals.
*** Significant at 1% significance level.
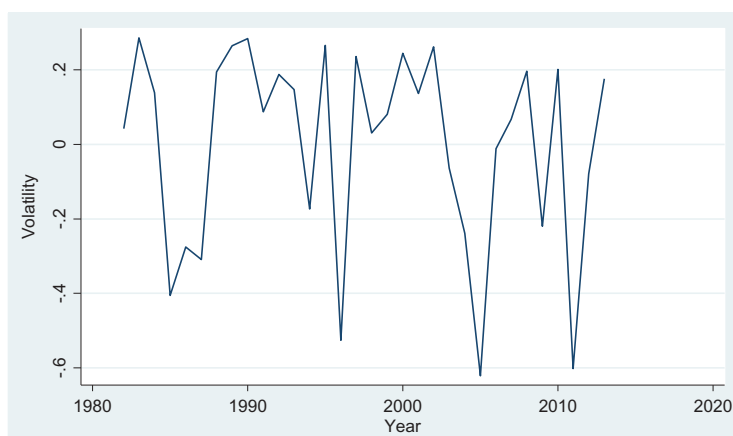
Figure 1. Conditional Real Exchange Rate Volatility.

changes in exchange rate shock is followed by large (small) changes over a longer period. The volatility clustering is obvious from Figure 1. Similar to most financial and economic time series variables, the exchange rate exhibits significant periods of high volatility followed by relatively more tranquil periods of low volatility.

The conditional real exchange rate volatility is presented above with the hope of providing some insights on the degree of exchange rate risk at least over the sample period. Overall, exchange rate has been very volatile. The change from fixed to "managed" floating regime in 1986 saw a sharp decline in volatility followed by marginal rise. The volatility trend shows a visible but sharp decline in 1995 to 1996, perhaps due to the abolishing of a wholesale auction system which ushered both the commercial banks and foreign exchange bureaux into a competitive financial environment. This period is followed by a modicum of stability until another deep spike is observed in 2004 to 2005. This downward trend could be attributed to the election and post-electoral period where government incurred higher expenditure thus contributing to currency depreciation.

5.3. *Unit root and cointegration tests*

We conducted the unit root test in two forms: first with constant and no trend; and second with constant and trend. The ADF test reveals non-stationary variables in their levels. However, all the series attained stationarity upon first differencing and are integration of order one, $I(0)$ by implication.[2] The results of the Johansen cointegration test based on the trace test are shown in Table 4. The test determines whether or not there exists a long-run relationship among volatility, output, FDI and portfolio investment, money supply, interest rate and terms of trade. We start with the null hypothesis of no cointegration and conclude on the existence of at least one cointegrating vector if the null hypothesis is rejected. The aim of this study is not to analyze the interaction between the variables, but to establish whether there is a long run relationship between the variables.

Table 4. Johansen Trace Cointegration Test

Null Hypothesis	Maximal Eigenvalue	Trace Statistics	0.05 Critical Value	Prob.**
r = 0	0.664571	113.2595	95.75366	0.0018*
r ≤ 1*	0.613556	79.39682	69.81889	0.0071*
r ≤ 2*	0.507551	49.92297	47.85613	0.0315**
r ≤ 3	0.375263	27.96366	29.79707	0.0802
r ≤ 4	0.263130	13.38047	15.49471	0.1016
r ≤ 5	0.118636	3.914819	3.841466	0.1479

Note: * Significant at 1% significance level; ** Significant at 5% significance level.

From Table 4, the null hypothesis of no co-integration is rejected at conventional levels from both the trace statistic and the maximal eigenvalue statistics, suggesting at most three cointegrating equations. This finding provides evidence of a long-run relationship among Ghana's exchange rate fluctuation and the selected macroeconomic variables. Given that the variables move together in the long run, we estimate a VECM and the results are shown below.

5.4. *Drivers of real exchange rate volatility*

Using the results obtained from the VECM, Table 5 reports the variables that determine the short-run volatility of exchange rates. We also report the error correction term indicating how short–run deviations are corrected according to the speed of adjustment.

The value of the R^2 indicates that about 20% of the variation in exchange rate volatility is due to variations in the independent variables. The overall model significance is checked relying on χ^2 and *p*-value which show that our variables are jointly significant at 10% level. Results from the VECM reveal that terms of trade, money supply, government expenditure and the proxy for the international financial integration – FDI and portfolio investment – positively affects volatility albeit insignificantly. The insignificance of these shows that in the short run, these variables are weakly exogenous and do not explain the short-term volatility. The coefficient of output is negative and significant at a 5% level suggesting that decrease in output increases volatility in exchange rate. The coefficient of the error correction term (ECT) is negative and significant indicating that following a short run exchange rate shock, about 6.9% deviation from long run equilibrium is corrected per annum and takes approximately

Table 5. Drivers of Real Exchange Rate Volatility

Variable	Coefficient	Stand. Error	z–statistic	p–value
Constant	−0.076	0.052	−1.47	0.142
FDI	0.068	0.054	1.27	0.206
Government expenditure	0.015	0.014	1.07	0.312
Output	−0.025	0.002	−11.59	0.000*
Money supply	0.013	0.011	1.26	0.208
Terms of trade	0.007	0.010	0.65	0.518
ECM	−0.069	0.041	−1.70	0.090***
R^2	0.202		HQIC	−14.471
χ^2 [*p*–value]	7.6097 [0.022]		SBIC	−13.950
AIC	−14.729		Log Likelihood	252.6589

Note: * Significant at 1% significance level; *** Significant at 10% significance level.

Table 6. Normalized Cointegrating Equation.

Variable	Coefficient	Stand. Error	z–statistic	p–value
Constant	70.704	–	–	–
FDI	0.879	.409	2.15	0.032**
GEXP	5.058	1.709	2.96	0.003*
OUTPUT	−10.146	2.040	−4.97	0.000*
MS	6.686	1.944	3.44	0.001*
TOT	−9.070	1.743	−5.20	0.000*

Notes: RGDP=real GDP, ERV=real exchange rate volatility; GEXP=government expenditure; GFCF=gross fixed capital formation; INFL=inflation; LAB=labour; OPEN=trade openness; DOMCR=domestic credit; INTR=interest rate.
** Significant at 5% significance level; * Significant at 1% significance level.

14.5 years for all disequilibrium to realign fully to the long-run equilibrium. While this is the case, we further report the normalized cointegrating equation in Table 6 by normalizing the volatility since the interest lies on the drivers of volatility relying on the endogenous variables.

The effect of output remains robustly negative and significant (at 1%) suggesting that volatility reduces (increases) in response to higher (lower) productivity. The results also show a negative and significant relationship between terms of trade and real exchange rate volatility. The implication is that an improvement in terms of trade reduces volatility. A plausible reasoning for this is as a result of improvement in external purchasing power capacity which reduces import prices. The coefficient of FDI is positive and statistically significant implying that integration into the international financial market increases long-run volatility. The effect of government expenditure is positive and significant at 1% suggesting that an expansion of government consumption expenditure increases exchange rate volatility. Here, demand factor – government expenditure – has similar effect as real effect. Nominal shock such as growth in money supply is positively associated with long-run exchange rate movements. A plausible explanation for this is that, the expansion in government expenditure increases the overall demand for non-tradable goods.

These findings thus suggest the importance of domestic real shocks affecting demand and supply as well as external and nominal shock in influencing long-term fluctuations in real exchange rate volatility. It is imperative to note that inferences on our parameters of the adjustment coefficients depend critically on the stationarity of the cointegrating equation. We thus present the cointegrated graph equation in checking the model specification.

5.5. *Forecast error of volatility*

In order to get a fair view of the contribution of the variables to shocks in the exchange rate we employ variance decomposition. We examine the dynamics of the VAR by looking at the proportion of the movements in the real exchange rate volatility that are due to "own" shocks, versus shocks to the other variables. The question we pose at this stage is, "how much of the *s*-step ahead forecast error variance of exchange rate volatility is explained by innovations in output, FDI among others?" As discussed in Koop, Pesaran, and Porter (1996) and Pesaran and Shin (1998), the ordering of the variables is important in deriving the *s*-step ahead forecast error variance decompositions. To this end we carry a Cholesky decomposition of the variance–covariance matrix of error terms to orthogonalize shocks. We decompose the error variance by
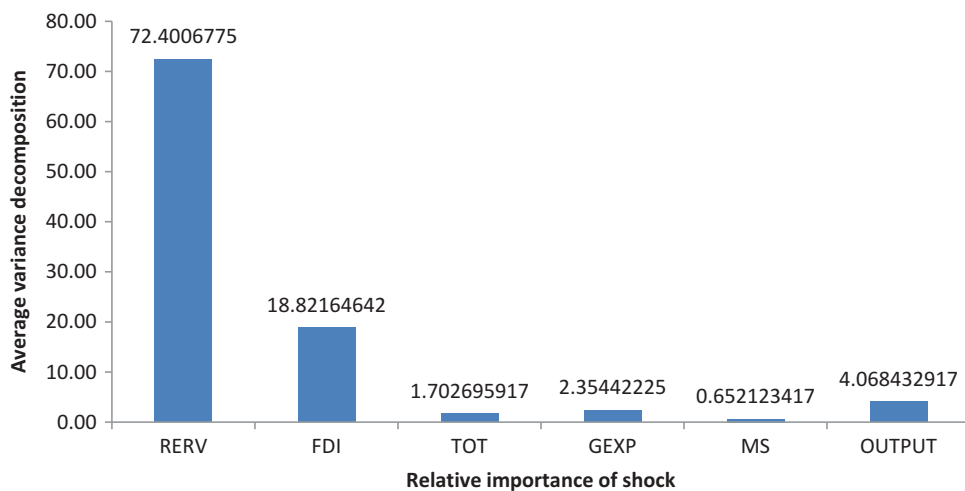
Table 7. Variance Decompositions.

Period	S.E	RERV	FDI	TOT	GEXP	MS	OUTPUT
1	0.2669	100.00	0.0000	0.0000	0.000000	0.0000	0.0000
2	0.3274	93.956	3.4146	0.2857	1.838105	0.0597	0.4454
3	0.3607	85.560	9.3807	0.4187	2.888755	0.3498	1.4009
4	0.3851	78.086	15.419	0.3688	2.964932	0.6828	2.4779
5	0.4046	72.405	20.100	0.4733	2.717976	0.8786	3.4240
6	0.4209	68.315	23.139	0.8911	2.533386	0.9327	4.1873
7	0.4349	65.421	24.837	1.5356	2.483144	0.9129	4.8089
8	0.4472	63.377	25.647	2.2398	2.512597	0.8720	5.3505
9	0.4582	61.908	25.956	2.8794	2.559323	0.8319	5.8650
10	0.4684	60.801	26.020	3.4031	2.589213	0.7968	6.3886
11	0.4780	59.895	25.992	3.8108	2.592781	0.7665	6.9415
12	0.4874	59.079	25.950	4.1257	2.572855	0.7414	7.5305
Average		72.40	18.82	1.70	2.35	0.65	4.07

Note: RERV=real exchange rate volatility; FDI=foreign direct investment; TOT=terms of trade; GEXP=government expenditure; MS=Money supply.

focusing on the real exchange rate volatility variable. The results are reported in Table 7.

The variance decompositions suggest that shocks to exchange rate are typically driven by its own volatility especially in the first period where it fully accounts for all its own volatility. Conversely, in the second period, exchange rate volatility explains about 94% of its volatility while FDI and government expenditure respectively (and marginally) accounts for about 3% and 5%. Apart from volatility itself, further results show that FDI significantly explains majority of the variance error of volatility relative to other variables. Money supply does not explain any significant variance of the exchange rate as its relative importance is less than 1%. However, while its ability to explain its volatility consistently decreases over time, it nonetheless explains majority of its volatility and by the end of the twelfth period.

Figure 2 presents the average variance decomposition over 12 periods which clearly indicates that 72% of the volatility in real exchange rate is largely explained by itself

Figure 2. Average Variance Decompositions over 12 Periods.

while 18.8% and 4.07% are respectively explained by changes in FDI and output with money supply explaining the least (0.65%). While real shock emanating from terms of trade significantly drives long-run exchange rate volatility, its contribution to overall exchange rate variance is only 1.7%.

5.6. *Effect on growth of exchange rate volatility*

While the preceding sections the documents the sources of real exchange rate volatility, the question of whether real exchange rate volatility affects economic growth remains an empirically unverified claim. Anecdotally, the uncertainty introduced by large swings in exchange rates affects investment and consumption decisions. These in turn may impact on economic growth performance. To guide policy, a clear understanding of the nexus between exchange rate volatility and economic growth is therefore important. The next section systematically examines the effect of real exchange rate volatility on economic growth. Table 8 reports the GMM results of three different specifications of the effect of real exchange rate volatility on economic growth. The Hansen test of over-identifying restrictions is used to assess the overall validity of the instruments with the lags of the independent variables used as candidates for the instruments. The low J statistics and the high *p*-values in all the models fail to reject the null hypotheses – evidence that our set of instruments is valid. The R-squares indicate that over 90% of the variation in growth is explained by variations in the independent variables. Furthermore, the high (low) Wald χ^2(p-values) shows the overall significance of the model.

The coefficients of the lagged dependent in all the models are positive and statistically significant suggesting that past values of economic growth positively influence current growth although the effects are less than unity. In model 1, our results indicate

Table 8. Effect of Real Exchange Rate Volatility on Growth – GMM Estimations.

Variable	1	2	3
Constant	−4.144 (3.201)	−4.015 (1.734)	−0.292 (1.607)
RGDP$_{t-1}$	0.706 (0.255)*	0.669 (0.152)*	0.913 (0.113)*
RERV	−0.008 (0.004)**	0.019 (0.032)	−0.114 (0.042)*
GEXP	0.079 (0.064)	0.070 (0.046)	0.003 (0.030)
GFCF	0.036 (0.037)	0.031 (0.025)	0.005 (0.025)
INFL	−0.024 (0.007)*	−0.023 (0.008)*	−0.083 (0.023)*
LAB	2.818 (2.231)	2.814 (1.211)**	0.344 (1.076)
OPEN	0.029 (0.022)	0.043 (0.029)	0.163 (0.045)*
DOMCR	0.070 (0.029)**	0.075 (0.023)*	0.057 (0.022)*
RERV square		0.004 (0.005)	0.019 (0.006)*
Interactions/Transmission channels:			
RERV*INFL			−0.023 (0.008)*
RERV*INTR			0.007 (0.004)***
RERV*TRAD			0.021 (0.011)***
R^2	0.990	0.991	0.993
Wald χ^2	7240.45	5815.73	7683.08
p – value	0.000	0.000	0.000
Hansen's J statistic χ^2 [p – value]	8.528 [0.202]	9.783 [0.201]	9.321 [0.231]

Notes: Dependent variable is log of real GDP per capita. Values in () are robust standard errors. RGDP=real GDP per capita, ERV=real exchange rate volatility; GEXP=government expenditure; GFCF=gross fixed capital formation; INFL=inflation; LAB=labour; OPEN=trade openness; DOMCR=domestic credit; INTR=interest rate.
* Significant at 1% significance level; ** Significant at 5% significance level; *** Significant at 10% significance level.

that real exchange rate volatility negatively and significantly affects growth suggesting that volatility is deleterious to long-term growth. In particular, a 1% increase in volatility reduces growth by 0.8%. Inflation negatively influences growth implying that macroeconomic instability is inimical to growth where a unit-percentage increase in inflation significantly reduces growth by 2.4%. Domestic credit is however growth-enhancing as its coefficients are positive and significant in all the models. However, gross fixed capital formation, government expenditure, labor and trade openness are not significant drivers of growth.

Model 2 includes a quadratic term of exchange rate volatility and the results show a positive effect of volatility and its square on growth. However, none of these are statistically significant. The effect of labor on growth is positive and gains significance when the quadratic term is controlled for. In model 3, we examine the transmission channels of volatility on growth. Here, the effect of volatility is negative and significant (at 1% level). However, its quadratic term is positive (and significant at 1%) suggesting that volatility–growth nexus is intrinsically non-linear and U-shaped in particular.

Trade openness is positive and significant when the transmission channels are controlled for. The coefficients of all the channels are significant. The interaction term of volatility and trade is positive suggesting that real exchange rate fluctuations affect growth by impacting on the competitiveness of domestic export and import competing firms. However, excess volatility deteriorates competitiveness thus lowering firms' profits. Volatility also affects growth by lowering macroeconomic instability proxied by inflation. Interestingly, real exchange rate volatility by increasing interest rates. The implication is that sharp depreciation (appreciation) which raises (reduces) interest rates increases (decreases) capital inflows hence affecting growth.

6. Policy implications of the causes and effects of exchange rate volatility

Based on the results of our empirical analysis we highlight the drivers of exchange rate volatility in Ghana in the short and long run. We also examined the important channels of the effect of exchange rate volatility on economic performance. Given the overall objective of this research, we then examine the policy implications of our findings to help guide economic policy.

So far the literature is inconclusive on the drivers of exchange rate volatility. Focusing on the Gh¢/US$ exchange rate our study indicate that in the short run monetary variables are not significant in driving exchange rate volatility. It has been taken for granted in the international macroeconomics literature that a high correlation between the nominal and real exchange rate is evidence in support of the overshooting model of Dornbush (1976) which emphasizes monetary shocks and sticky prices. However, shocks to taste, technology, fiscal and trade may even be more important than monetary shocks particularly for developing countries. This statement holds irrespective of the exchange rate regime a country operates (see Stockman, 1987, 1988). The most important driver of exchange rate volatility in Ghana is changes in output. We particularly found an inverse relationship between output and real exchange rate volatility, suggesting that decreases in output heighten volatility in real exchange rates. From the traditional monetary version of exchange rate volatility, one should expect these shocks to manifest in nominal exchange rates as the authorities attempt to

stabilize the price level. However, we do not see this in the Ghanaian case. Rather we document that output fluctuations mirror in weakening economic fundamentals, including wide movements in exchange rates. In the era of flexible regimes,[3] output fluctuations should be moderated by changes in the nominal exchange rate, since that is probably the strongest appeal of floating exchange rates in the first place. To this end, interventions, whatever their motivations to short run output fluctuations, first may be too costly, and second may not necessarily yield the intended benefits. In the light of our findings, therefore, optimal policy should be one that focuses on the source of the output fluctuations rather than intervening in the foreign exchange market. More importantly, the impact of the ongoing energy crisis and its attendant effect on domestic firm performance, the increasing deterioration in productivity may be impor- tant avenues of concern. We therefore hold the view that interventions such as those introduced by the Bank of Ghana in February 2014 to stem the tide of the depreciating Cedi typically came too late to prevent severe currency misalignments.[4] These inter- ventions, in turn, may exacerbate the currency depreciation and trigger major economic distortions such as increased black market transactions. And as emphasized by Tweneboah and Alagidede (2015), a switch to a more stable international currency such as the US dollar by domestic agents may ensue if volatility is excessive.

One important implication of our results on the financial sector is the finding that portfolio flows is not important driver of exchange rate volatility in the short run. In contrast to large emerging markets where hot money inflows tend to cause large swings in the exchange rate, Ghana's relatively small and illiquid financial sector seem to be insulated from the ravages of hot money flows. Apart from not receiving sufficient hot money flows, the few that do flow into the economy are not of the disruptive type.

We show that a shock to the terms of trade affect volatility of exchange rate in the long run. Government spending also affects the exchange rate only in the long run. Consistent with theory, a shock to the exchange rate tends to mean revert. Our estimates indicate that about 6.9% deviation is corrected per annum. And this takes approximately 14.5 years for all disequilibrium to realign fully to the long-run equilibrium. Although flexible exchange rate allows relative prices to adjust through changes in the nominal exchange rate, the rather long period and slow adjustment process could have severe welfare implications for producers and consumers as the effects of large swings in the exchange rate impact on input prices, amplify investment uncertainties and impact on consumption decisions. Summarizing the main drivers of exchange rate volatility, we note that own volatility tends to be more important than real and nominal factors in Ghana. This is estimated to be over 70% from our variance decomposition. The rather large impact of own shocks clearly highlights the important role of speculators, noise and fads in the foreign exchange market in Ghana. We posit that some of these could be due to microstructure biases and the activities of uninformed traders in assimilating macroeconomic news. This finding opens the door for further studies on the role of speculation and noise in exchange rate dynamics in Ghana. Overall we show that FDI, output and government expenditure are important drivers of exchange rate volatility, accounting for 19, 4.1, and 2.4% respectively. Terms of trade (1.7%) and money supply (0.7%) account for the remaining volatility of real exchange rates. In the long run therefore, both real and monetary factors are important in explaining exchange rate volatility.

On the exchange rate volatility–economic growth nexus, our study found a negative and significant relationship between the two. We conjecture a number of possible channels through which this can occur in practice after implementing a bunch of controls in our regressions. One channel is through trade which has been addressed in a vast number of studies (see Arize et al., 2000; Dell'Ariccia, 1999; McKenzie, 1999) and confirmed by this current study. As a commodity dependent country if commodity traders are sufficiently risk averse (or even risk neutral), higher exchange rate volatility may lead to a reduction in the volume of trade as agents expected profits may be negatively affected (see Brodsky, 1984). Greater volatility may even lead economic agents to demand higher prices to cover their exposure to currency risk. This may then put pressure on the domestic price level. These connections are at the heart of the recent experience of the Ghanaian economy.

The net effect of our study establishes that excessive volatility is detrimental to growth. But is this always the case? If indeed the answer was in the affirmative, the consequences could be great. However, our study confirms that, exchange rate volatility–economic growth nexus is U-shaped. In other words, real exchange rate volatility is detrimental to growth up to a certain threshold where it begins to positively influence long-term growth. Thus higher volatility does not always hurt growth. For instance, greater exchange rate fluctuations could lead to a more efficient resource allocation thus propelling growth. Furthermore, excessive volatility could promote firm innovation and productivity as domestic firms cannot fully rely on the undervalued exchange rates and intervention in foreign exchange market in order to maintain international competitiveness.

To the extent that variation in real exchange rate is largely accounted for by its own volatility, and the impact of exchange rate volatility on growth is non-linear, a number of policy insights can be gleaned by domestic policy authorities such as the Bank of Ghana. What is the optimal way to intervene in the exchange rate market? Our study suggests that as long as a floating exchange rate regime prevails, shocks to the exchange rate can be self-correcting. Continuing exchange rate interventions especially the unsterilized type are more likely to yield excessive real exchange rate volatility. Own volatility suggests that most of the news is not adequately reflected in the foreign exchange market. Transparency of forecast and policy decisions would help the public and markets understand central bank's actions thus decreasing the level of uncertainty and speculation.

Finally, the ultimate way for conducting an effective monetary policy requires policy makers to factor asset prices and exchange rate in particular in setting monetary policy instrument as this is in sync with the inflation targeting.

7. Concluding remarks

This study analyzed the causes of real exchange rate volatility and its effect on economic growth in Ghana relying on annual data spanning 1980 to 2013. Exploiting techniques from the time series literature, our results revealed that in the short run output is the main driver of exchange rate fluctuations in Ghana. In the long run, however, exchange rate volatility is significantly influenced by government expenditure growth, money supply, terms of trade shocks, FDI flows and domestic output movements. Decomposing the shocks indicates that almost three quarters of exchange rate volatility are self-driven. The remaining one quarter or so is accounted for by the factors alluded

to previously. The implication of the results is that since exchange rate volatility is almost self-driven, unbridled interventions may not only exacerbate volatility, but may also be costly in terms of output and welfare. Improving exchange rate modelling and forecast at the central bank level, while incorporating the impact of asset prices in domestic monetary policy could improve both the transparency and functioning of the foreign exchange market.

Notes

1. There have also been excellent discussions on carry trade–exchange rate volatility nexus (see Menkhoff et al., 2012; Cenedese, Sarno, & Tsiakas, 2014).
2. For brevity, we do not report the unit roots results but these are available upon request.
3. Under a fixed regime, the domestic authorities could potentially respond to stem the tide of loss international reserves to forestall devaluation. Optimizing agents foresee that the authorities would take these actions to stabilize the exchange rate. This may either lead to a self-fulfilling crisis whether the expectation of further depreciation leads to speculative attacks and abandonment of the peg, or on the positive side, the expectation of the authorities' intervention stabilizes the exchange rate at its current equilibrium level.
4. Mpundu Chipili (2014) also assesses the impact of central bank of Zambia's intervention on the volatility of the exchange rate and found a statistically weak negative impact of inter-vention on exchange rate volatility, suggesting that other important policy instruments are required to augment foreign exchange interventions in taming exchange rate volatility.

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Appendix

Table A1. VAR Lag Order Selection Criteria.

Lag	LogL	LR	FPE	AIC	SC	HQ
0	96.74930	NA	9.50e-11	−6.049954	−5.769714	−5.960303
1	262.2468	253.7629*	1.78e-14*	−14.68312	−12.72145*	−14.05556*
2	295.2557	37.41006	2.98e-14	−14.48371	−10.84060	−13.31825
3	345.2386	36.65410	3.18e-14	−15.41590*	−10.09135	−13.71253